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Synthesis of maleimide modified imidazole derivatives and their application in one-component epoxy resin systems

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ABSTRACT

A series of novel maleimide modified imidazole derivatives were successfully synthesized through the addition reaction between N-(4-hydroxyphenyl) maleimide (HPM) and imidazole compounds with 1-position N—H bond. The maleimide modified imidazole derivatives were blended with epoxy resin (EP) to evaluate their reactivity and thermal latency. Compared with the common EP/imidazoles systems, the curing exothermic interval of the EP systems containing maleimide modified imidazole derivatives shifted to higher temperature regions. Moreover, the EP systems containing maleimide modified imidazole derivatives had much longer pot life under room temperature. The enhanced latency of maleimide modified imidazole derivatives was attributed to the strong electron withdrawing effect of maleimide group, which reduced the nucleophilicity of imidazole moiety. Notably, the maleimide modified imidazole derivatives regained fast curing ability towards EP by overcoming the curing reaction energy barrier under heating condition.

1. Introduction

As a new generation of lightweight material, carbon fiber reinforced plastic (CFRP) has broad application prospect in vehicle, rail transit, ship and other fields. However, the low molding efficiency of CFRP limits its large-scale application in these fields [1–3]. Prepreg forming process is one of the leading molding methods of CFRP due to its advantages of simple operating procedure, little environmental pollution, stable product quality and convenience for large-scale industrial production, and epoxy resin (EP) is one of the most commonly used matrix resin of prepreg due to its excellent comprehensive properties. Therefore, the latent curing agents with fast curing ability have become a research hotspot in the field of EP based carbon fiber prepreg.

In recent years, imidazole derivatives have attracted widespread attention of researchers since they can rapidly cure EP within several minutes by inducing anionic chain polymerization of epoxy groups [4–7]. However, the intrinsic high curing activity of imidazole derivatives limits their application in one-component EP systems, since the EP systems containing the common imidazoles always gradually transform into indissoluble cross-linked networks in a short period of time even at room temperature [8]. Based on the previous studies, the curing activity of imidazole derivatives can be altered by introducing other chemical groups into their molecular structures. Introducing substituent groups on the imidazole ring through the reactivity of 1-position and 3-position nitrogen atoms is an effective way to prepare imidazole type latent curing agents [9–15]. If the introduced substituent groups reduced the nucleophilicity of imidazole moiety, the latency of imidazole curing agents would be improved [16]. On the basis of this strategy of molecular design, we intended to prepare latent imidazole curing agents through the addition reaction between N-(4-hydroxyphenyl) maleimide (HPM) and imidazole compounds with 1-position N—H bond. It was expected that the electrophilic maleimide group would restrain the curing activity of the imidazole moiety. The curing behaviors and storage stability of the EP systems containing maleimide modified imidazole derivatives were investigated.

2. Experimental

Synthesis of maleimide modified imidazole derivatives: The target products were synthesized via the addition reaction of N-(4-hydroxyphenyl) maleimide (HPM) with imidazole (IM),

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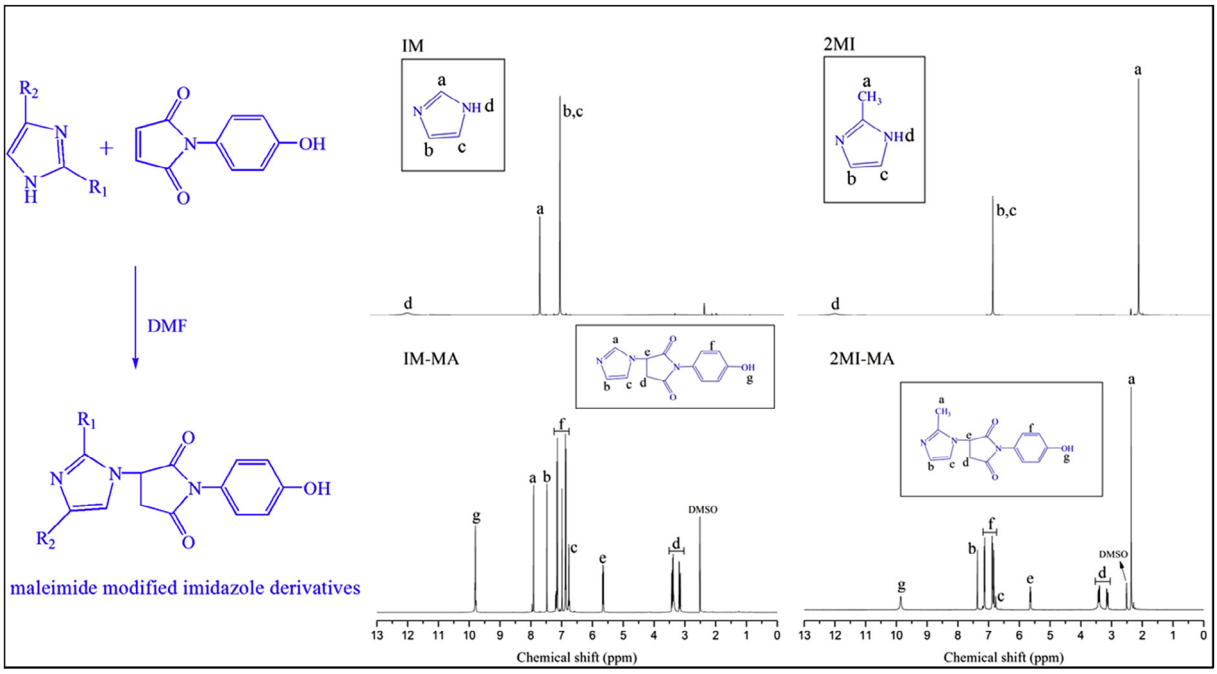

Fig. 1. Synthesis route of maleimide modified imidazole derivatives and ^{1}H NMR spectra of IM, 2MI, IM-MA and 2MI-MA.

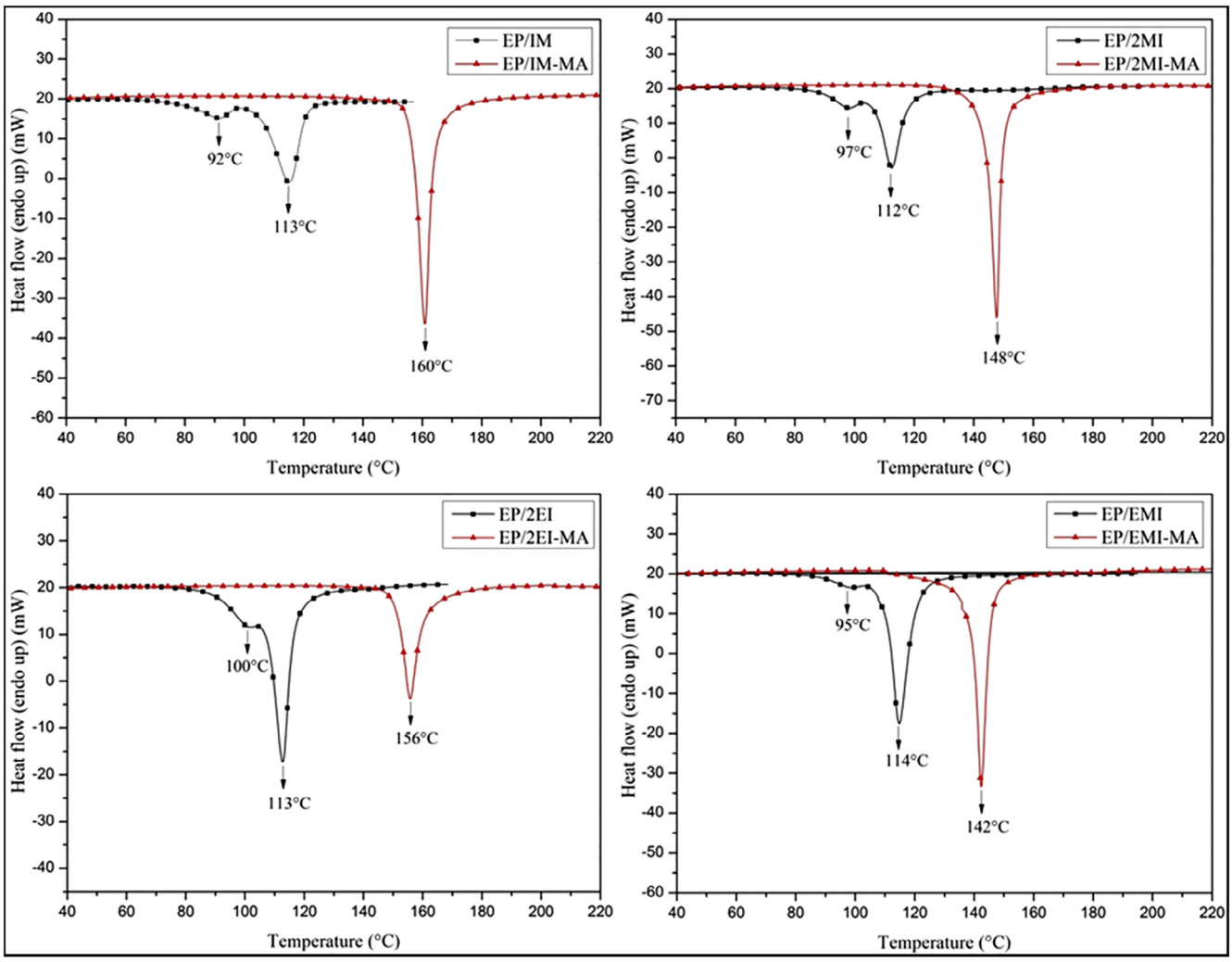

Fig. 2. Dynamic DSC curves of the prepared EP systems.